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EFFECTS OF DRUGS ON HUMAN PERFORMANCE**Analytic Techniques, New Test Development, and Further Studies****SECOND ANNUAL REPORT**

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31 August 1966

U. S. ARMY EDGEWOOD ARSENAL RESEARCH LABORATORIES

Edgewood Arsenal, Maryland 21010

Contract No. DA 18-035-AMC-282(A)

AIR-E-25-8/66-AR-2

AMERICAN INSTITUTES FOR RESEARCH

Washington Office

8555 Sixteenth Street

Silver Spring, Maryland 20910

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FOREWORD

The work described in this report was authorized under Contract No. DA 18-035-AMC-282(A). This work was started in July 1964 and is in progress. This report covers the period from 23 July 1965 to 23 July 1966.

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PREFACE

The present report describes the second year of research carried out by the American Institutes for Research (AIR) with the collaboration and support of the Psychology and Psychopharmacology Branches of the U. S. Army's Edgewood Arsenal Research Laboratories (EARL). The project was administered within AIR's Skills Research Program, whose director is Dr. Harold P. Van Cott.

At EARL, we are grateful for the support and assistance of the Contract Project Officer, Dr. Milton Joffe; of the Psychology Branch headed by Lt. Col. George Crampton, and including Capt. Harlan Linsley and Lt. Ron Smith; and of the Psychopharmacology Branch, who provided full medical support throughout the studies conducted. Major James Ketchum, head of the Branch and of the Clinical Research Department greatly facilitated our work, especially in providing a conscientious and professional team of nurses, headed by Mrs. June Brenneman, to work as test administrators; Mrs. Pat Allen, Mrs. Nancy Bowman, Mrs. Virginia Hagen, Mrs. Lorraine Haskins, Mrs. Josephine Magness, Mrs. Anne May, and Mrs. Carol Riley.

At AIR, we appreciate the data processing services of Miss Bonnie Rininger and Miss Arlene Geist, and the administrative and secretarial support of Mrs. Nancy Brown and Mrs. Doris Donohue.

Finally, we acknowledge the continuing assistance and supervision of the Principal Investigator, Dr. Edwin A. Fleishman, Vice President and Director of AIR's Washington Office, who, with Dr. Edward Stearns, former Head of EARL's Psychology Branch, initiated and guided the project through its first year.

DIGEST

The aim of the project is the development of a comprehensive test battery to study the effects of incapacitating drugs on the abilities that are basic to military performance.

The project's three major objectives are:

1. Establishment of a Human Performance Test Laboratory at Edgewood Arsenal, which incorporates a basic abilities battery.
2. Evaluation of the use of the battery with a wide range of chemical agents.
3. Evaluation of the laboratory results in terms of their generalizability to military tasks.

This report summarizes progress in the second year's effort which concentrated on the second objective, but which continued to develop new tests, and which initiated the testing of drug effects on prototype military tasks. The major accomplishments were the following:

1. Completion of detailed analyses of data collected during the first year, resulting in refinement of data analysis techniques, development of indices of drug effects in terms of percentage of subjects affected, and evaluation of established tests.
2. Study III: "A Feasibility Study of the Use of Corrective Lenses with Drugged Subjects."
3. Preparation of a Test Administrator's Manual, to which supplements will be added as new tests are developed.
4. Conduct of Study IV: "The Effects of Medical/Psychiatric Classification on Group Differences in Performance" (EARL Research Plan 3144).
5. Conduct of Study V: "The Effects of 3530A on Selected Laboratory and Field Tests" (EARL Research Plan 11301).
6. Pilot testing of the Social Conformity Test Apparatus and recommendations for further use in Social Abilities testing.

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CHAPTER I

INTRODUCTION

The First Annual Report (Elkin, Fleishman, Van Cott, Horowitz and Freedle, 1965) on this project provided a comprehensive statement of the objectives of the present study, of the rationale used in the selection of tests, and of the initial efforts at test development and implementation in several experimental studies. Of fifty ability tests recommended, twenty were studied in three major experiments with scopolamine, and in three exploratory studies with other agents of interest to EARL. Of the five ability areas delineated (psychomotor, physical proficiency, sensory-perceptual, cognitive, and social), by far the greatest number of tests were developed in the psychomotor and physical proficiency areas where previous studies had most clearly identified basic abilities and specified their tests.

These tests, in the psychomotor area, included measures of: manual dexterity, finger dexterity, multiple-limb coordination, reaction time, and arm-hand steadiness; in the physical proficiency area they included measures of: static strength, dynamic strength, static flexibility, dynamic flexibility, and gross body equilibrium. Fewer tests were developed in the sensory-perceptual (visual acuity, time estimation) and cognitive (number facility, short term memory) areas, and none were developed in the social area during the first year.

Two studies during the first year (Studies I and II) examined the effects of a 12 microgram/kilogram intra-muscular injection of scopolamine on performance. Technical Report I (Elkin, Freedle, Van Cott and Fleishman, 1965) covered the general results of the first study and indicated that the types of performance measured were affected by scopolamine,

that drug effects were generally most severe between 2 and 4 hours after drug administration, and that different tests showed different patterns of drug effect in terms of onset, severity, and duration. These preliminary analyses, however, only considered group trends and did not take subject differences into account. Since it was found that inconsistent individual differences from one time point to another were a prime source of variance in determining the effects of drugs on ability components, it was decided to devote considerable attention to this problem. Accordingly, early in the second year, a more thorough and detailed analysis of the data was carried out to give a clearer picture of the drug effects. Technical Report 2 (Baker, Elkin, Van Cott and Fleishman, 1966) provided this analysis, and raised other questions which determined much of what was done in the second year. Specifically, the first Technical Report examined only differences between control and experimental group means; the second report directed attention toward drug effects on individual subjects, isolating subject-by-treatment interactions, effects of replication of tests within test sessions, distinctions between experimental and sampling error, and estimates of test-retest reliabilities for the measures used. These analyses then led to recommendations for test modification, and for improvement in experimental design and control. The two major studies run this year (IV and V) implemented some of these recommendations.

CHAPTER II

SECOND YEAR RESULTS

A. Results of Re-examination of Study I and Analysis of Study II

The re-analysis of Study I data and the application of the methods developed for this to data from Study II led to a number of significant results. These included the development of a mathematical model on which to base subsequent analyses, specific evaluation of each of the tests leading to recommendations for improvements, the computation of a "per cent affected" index to describe the overall effect of a particular drug on a group of subjects at a given point in time, and the recommendation of ways in which the experimental design and controls could be improved so that the effect of the drug on performance could most clearly be seen and distinguished from the effects on performance of other variables.

Table I summarizes the recommendations made for improvement of each ability test used in the first year, including its estimated reliability, and the problems, if any, that were noted. The details of the analysis and the reasoning that led to the recommendations are incorporated in Technical Report 2 (Baker, et al., 1966).

One of the major concerns in Technical Report 2 was with the presence of a subject-by-session interaction in every test, indicating that subjects were reacting differently to the drug at different points in time. Accordingly, each subject's test scores were analyzed to determine which among them were, and which were not, showing performance decrement on the different tests and test sessions.

In order to deal adequately with the interaction patterns, a "per

TABLE 2

Recommendations for Modifications of Tests Employed in Study I Based on Detailed Analyses of Performance Scores

Ability Measured	Test Name	Estimated Reliability	Major Problems Noted	Recommended Changes
1.1 Far Vis. Acuity	ORTHOPATER	.92	Inadequate ceiling	Develop different test of acuity to adequately test "better than average" subjects.
1.2 Near Vis. Acuity	ORTHORATER	.93	" "	
1.3 Manual Dexterity	MENT. MANIPULATION	.94	None	None
1.4 Static Strength	HAND DYNAMOMETER	.93	Control Group Interaction	Consider different test.
1.5 Gross Body Equilib.	BALANCE A	----	Inadequate ceiling	Extend trial time to 1 minute and/or require subjects to keep hands on hips.
1.6 Number Facility	ADDITION	.82	a. No replication within trials b. Untestable cases related to loss of visual acuity	a. Score odd vs. even items for number correct on each form. b. Modify test or treat Subjects to offset visual acuity losses observed.
1.7 Short Term Memory	AUDITORY NC. SPAN	.73	Scoring system may be too gross	a. Separate test items to form two series for each trial. b. Extend items to an 11 unit group; drop 3 unit group.
1.8 Time Estimation	EMPTY INTERVAL JUDGMENT	.72	Strong Control Group Interaction	Improve training by continuing to provide knowledge of results in all sessions of first day's testing.
1.9 Reaction Time	SIMPLE VISUAL REACTION TIME	.71	None	None

1. Average single session estimated reliability based on intra-class correlation coefficients as computed from control subject data.

TABLE 1 (Cont'd.)

Recommendations for Modifications of Tests Employed in Study II Based on Detailed Analyses of Performance Scores

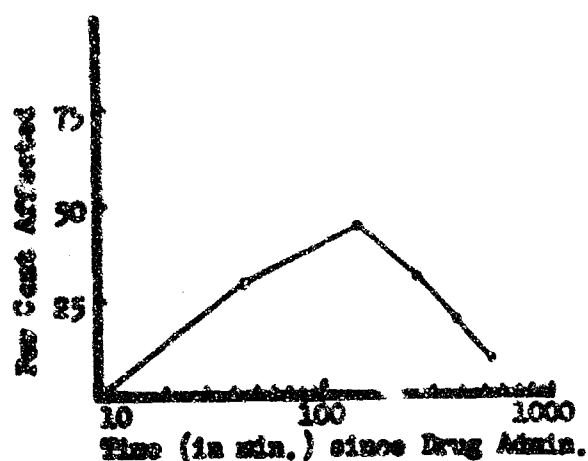
Ability Measure	Test Name	Estimated Reliability ¹	Major Problems Noted	Recommendations
2.1a Arm-Hand Steadiness	TRACK TRACING- 2.1a in error	.80	None	None
2.1b Arm-Hand Steadiness	TRACK TRACING- Number of errors	.20	Lacks reliability	Eliminate from battery is confirmed in next study.
2.2 Explosive Strength	BROAD JUMP	.86	Control Group Interaction	Give more explicit instructions to subjects.
2.3 Manual Dexterity	BLOCK TURNING	.86	None	Drop in favor of M.M. Hand. for better reliability.
2.4 Finger Dexterity	PURDUE PEGBOARD	.70	Poor Control Group Data	Use same form in next study.
2.5 Multilimb Coordination	TWO-HAND COORDINATION	.69	Strong Control Interaction	Eliminate from battery; would require extensive pre-training.
2.6 Dynamic Flexibility	BEARD, TWIST & TOUCH	.99	No replication	Replicate with two 20-second trials for each session.
2.7 Dynamic Strength	PULL-UPS	-----	Test too difficult for some underaged subjects	Drop from battery; substitute Bent-leg Hang Test.

¹ Average single session estimated reliability based on intra-class correlation coefficients as computed from control subject data.

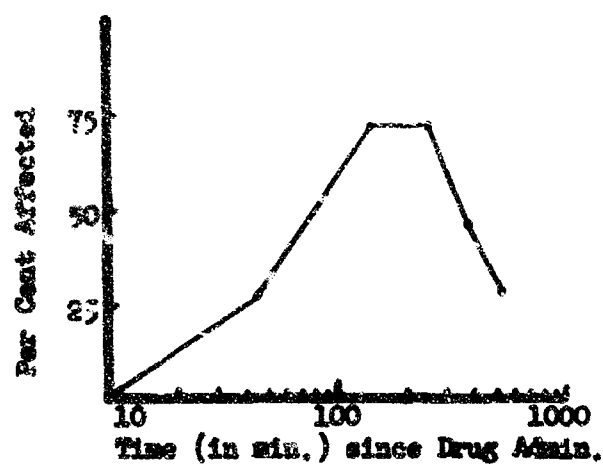
cent affected" index was developed to roughly characterize an operational effect for general reporting purposes. Then, a detailed examination of the diversity of the individual subject reactions led to questions concerning the adequacy of experimental controls, some of which might actually cause some of the observed diversity.

Operationally, a field commander's interest in the action of a given incapacitant is likely to center around two interrelated questions: "How many men are affected?" and "How are the men affected?" Glossing over the fact that different men react differently to any agent, it still is possible to state for each ability test, the proportion of men whose performance was significantly altered from its appropriate baseline value at some point in time, and this can be done separately for each ability of interest. This was the basis for the "per cent affected" index. A graph of this type of data is included as Figure 1 illustrating, in terms of the per cent of men affected, the magnitude of drug effects as a function of time since drug administration for six of the tests in Study I. The more detailed methods of analysis suggested in Technical Report 2 will provide answers to much more specific questions and should lead to a much clearer understanding of the nature of drug effects on human performance.

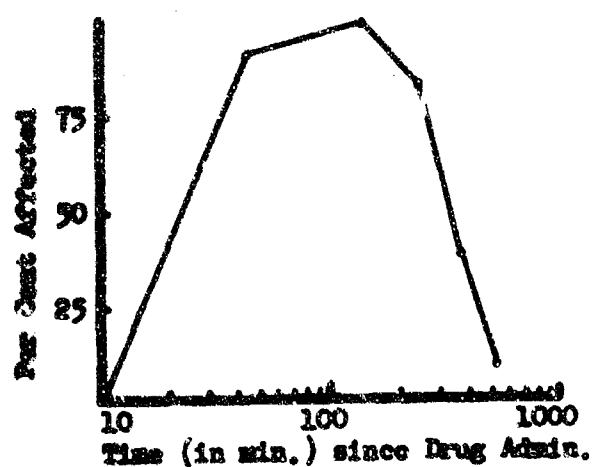
The graphs in Figure 1 clearly demonstrate the differences in the drug effects on the various ability tests. It should be remembered, however, that the same man or men are not necessarily affected across the time points or on the several variables at any point in time. Each data point plotted simply represents a count of the number of men affected on that variable at that point in time. The index does not take into account the differences that appear in the individual reactions and may, in fact, mask such differences which are of considerable importance in any attempt to predict the effects of the drug on field performance based on



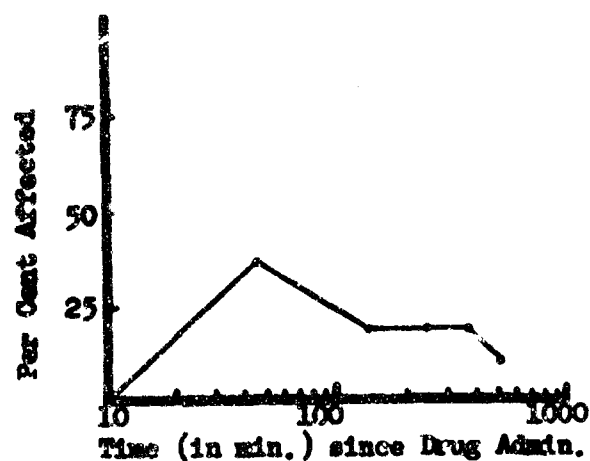
(a) FAR VISUAL ACUITY



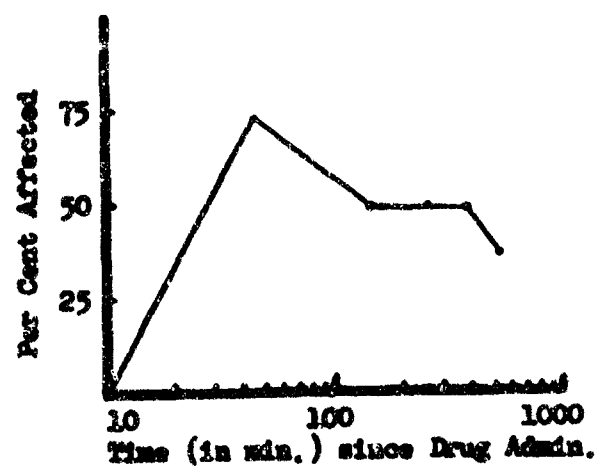
(b) NEAR VISUAL ACUITY



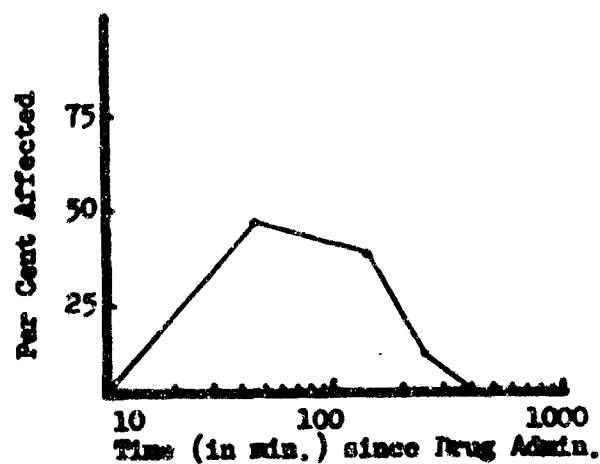
(c) MANUAL DEXTERITY



(d) STATIC STRENGTH



(e) TIME ESTIMATION



(f) SIMPLE REACTION TIME

Figure 1. Per cent of man affected as a function of time since drug administration in Study I.

changes in the laboratory test results.

B. Study III: A Feasibility Study of the Use of Corrective Lenses with Drugged Subjects

It is obvious, when multiple measures are taken on subjects under the influence of drugs, that changes in one mode of performance are not totally independent of changes in another. This is most apparent when the agent of interest adversely affects visual acuity and paper-and-pencil tests are employed to measure other ability losses. Speculations on the possible use of corrective lenses to restore normal acuity led to the running of a small pilot study to see if the technique were feasible.

As is indicated in Technical Report 3 (Elkin and Freedle, in press), it was possible in some cases to improve visual acuity for subjects treated with scopolamine, but usually impossible to restore normal visual acuity levels for most subjects. The fitting of corrective lenses proved difficult and time-consuming so that it would probably have to be classed as an impractical technique for routine laboratory use even though, potentially, some interesting research along these lines might be possible. The amount of partial restoration of vision varied from subject to subject. Thus, even though significant improvement in performance could be achieved with corrective lenses, the meaning of this improvement for the ability in question was ambiguous. The technique might be manageable with other agents, but it would probably be better to enlarge test materials to alleviate some of the problems with the type of agent used in this study.

C. Study IV. The Effects of Medical/Psychiatric Classification on
Group Differences in Performance

As a result of the data analyses from Studies I and II, it became evident that improvements in the test equipment and testing procedures could be made. These improvements were recommended in Technical Report 2. The report also pointed out that practical considerations surrounding the experiments often led to separating volunteers who were and were not eligible for psychoactive drugs into experimental and control groups respectively, forcing the assumption that the two groups were comparable in terms of performance. This comparability, however, had never been tested. The report went on to point out the value of testing for comparability in a non-drug study to establish the equivalence of the two groups in terms of general levels of performance.

Study IV provided an opportunity, not only to test the assumed comparability of groups but to check out the recommended test modifications and to train additional nurses as test administrators as well. A pilot version of a Test Administrator's Manual was prepared which included standardized instructions and scoring procedures for the tests to be given. The tests included measures of: short term memory, gross body equilibrium, dynamic flexibility, time estimation, static strength, manual dexterity, reaction time, explosive strength, and arm-hand steadiness. A group of five nurses from EARL's Medical Research Laboratory was trained in the use of the test manual, and some revisions were made in instructions in accordance with their recommendations.

For Study IV, five four-man groups were tested, each group completing nine test sessions in a two-day period. Of the 20 subjects tested, 10 would have been classed as eligible, and the other 10 as ineligible for use in studies employing psychoactive chemicals.

The data are currently being analyzed and will be reported on fully in Technical Report 4 (Baker and Elkin, in press) which will include the details of the experimental procedure, and a further evaluation of the tests used. In general, though, it was found that the two groups differed little in terms of the abilities measured. The one clear difference appeared in terms of static strength and indicated that eligible subjects, as a group, were consistently stronger than ineligible throughout the test period. Other than that, there was simply a general tendency for the ineligible to be slightly, but not significantly, more variable than the eligibles. This, of course, does not demonstrate that real differences on other variables would not be present.

D. Study V: Effects of 3580A on Selected Laboratory and Field Tests

This was one of the major research efforts of the second year on the project. It involved over 50 medical, nursing, professional, and support personnel in nearly six weeks of preparation and actual testing. For the study, AIR developed and supervised the implementation of a test schedule which integrated and coordinated the activities of the Psychology and Psychopharmacology Branches.

The study's aims were fourfold:

- a) to obtain data on the effects of a fixed dose of 3580A on tests from the AIR battery;
- b) to study the relation between the AIR tests and other standard performance tests presently in use at EARL;
- c) to develop prototype military criterion tasks, and to examine the effects of the agent on those tasks;
- d) to determine if subject-related characteristics such as body-weight and personality trait could be used as co-variables to control for the magnitude of subject-by-session interaction variances.

The study followed the basic design of earlier studies except that the control group was not given a placebo injection*, and drug subjects received a fixed amount of the agent of interest. Subjects were tested in four-man groups, each group undergoing $2\frac{1}{2}$ days of testing. The schedules for the groups overlapped on one day so that the four groups were run in two five-day periods. The first day for each group provided training on all tasks and tests, the second day served as the "drug day" during which two of the four men received an intra-muscular injection of 3580A, and the third day provided a final post-drug measurement of task and test performance. The measures taken during this study are listed in Table 2, and the full analysis of the drug's effects on these types of performance will be covered in Technical Report 5 (Baker, Elkin, Van Cott, and Fleishman, in press).

In addition to Technical Report 5, a technical note (Baker, in press) is also being written to specifically consider the comparison of responses obtained from this fixed-dose study as compared to similar data obtained in weight-adjusted dose studies. Analyses thus far completed for this note indicate that data gathered under the fixed-dose technique are less inconsistent from subject to subject, and that relations to subject characteristics other than body-weight are more relevant in controlling for such inconsistencies than is body-weight. This in turn suggests that the adjustment of the dose of a psychoactive chemical for body-weight can induce rather than eliminate undesirable variations in subject responses.

* The reasoning behind this change is given in Technical Report 2 (Baker, Elkin, Van Cott and Fleishman, 1966), pp. 14-16.

TABLE 2

Tests and Measures for Assessing Drug Effects in Study V

VITAL SIGNS	PERFORMANCE MEASURES		FIELD TESTS (Psychology Branch)
	"Standard" Tests (Psychopharm. Branch)	"Basic Abilities Tests" (AIR Battery)	
Blood Pressure			Grenade Throw
Pulse Rate	ZITA (Zero Input Tracking Analyzer)	NEAR & FAR ACUITY (Orthorater Test)	Gas-Mask Use
Respiration Rate			
Pupil Size	VITA (Variable Interval Time Analyzer)	MANUAL DEXTERITY (Minn. Manip.)	Rifle Loading
Auxiliary Temperature		STATIC STRENGTH (Hand Grip)	Rifle Firing
	NF (Number Facility)	GROSS BODY EQUILIBRIUM (Balance)	
		DYNAMIC FLEXIBILITY (Bend, Twist & Touch)	
		ARM-HAND STEADINESS (Track Tracing)	
		TIME ESTIMATION (Empty-Interval Production)	
		SHORT TERM MEMORY (Auditory Number Span)	

E. A Prototype Test for Studying Drug Effects on Social Conformity

The area of social interaction and the study of drug effects on such interaction are of potentially great importance to the military. Information about drug-induced degradation in performance of a scouting patrol or of a communications network could be valuable in planning a strategic maneuver. Unfortunately, the social area is the least well defined, and one of the hardest to handle experimentally, of all the human abilities. Some advances have been made, however, toward definition and quantification of social variables.

Although a full set of social abilities, *per se*, has not yet been identified, researchers have conceptualized a number of social behaviors that appear fundamental to many types of group performance, and have developed several tests of these behaviors. One such behavior is the susceptibility to social influence, and a test used to measure it is the Crutchfield Conformity Apparatus.

During the second contract year, this apparatus (modified slightly from its standard form for the purposes of EARL research) was procured and temporarily installed at AIR in order to initiate the development of test procedures and materials applicable to the study of drug effects on social conformity. The report of the progress made in this development and the recommendations for further work constitute Technical Note 1 (Horowitz, 1966), which includes suggestions for testing procedures, and for developing new stimulus materials. The report cautions, however, that since the apparatus has not yet been operationally evaluated with drugs, a pilot test program should be initiated prior to incorporating the test as part of the basic performance battery. Use of the Crutchfield apparatus and coordination with EARL in developing other social performance tests are envisioned as part of the third year's effort.

CHAPTER III

PLANS FOR THE THIRD YEAR

Although the third year effort will not be as comprehensive as was initially planned, AIR expects to continue work toward the same goals set forth in the Digest. Emphasis in new test development will be on broadening the sensory-perceptual and cognitive areas.

Efforts in the areas of new test development, of evaluation of test use with a variety of drugs, and in gathering background information on test validity will receive prime emphasis. New test development will concentrate on the sensory-perceptual and cognitive areas. Future drug studies will utilize these and the tests already established to gain additional information on drugs already studied (3580A), as well as on new drugs. Test validation work as such will not be performed. However, a literature survey will be conducted to examine and evaluate evidence for test validity found in previous studies. Although prime responsibility for developing the military criterion tasks has been transferred to EARL's Psychology Branch, AIR will coordinate closely with the Branch in planning and conducting studies to assess the predictability of drug effects on the military tasks based on the drug effects on the basic abilities which presumably underlie those tasks.

Throughout the third year, AIR will continue to support the Research Laboratory's test program by advising on statistical techniques and experimental design, and by providing recommendations regarding the ongoing development of the laboratories and test facilities.

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Unclassified

Security Classification

DOCUMENT CONTROL DATA - R&D

(Security classification of title, body of abstract and indexing annotation must be entered when the overall report is classified)

1. ORIGINATING ACTIVITY (Corporate author) AMERICAN INSTITUTES FOR RESEARCH		2a. REPORT SECURITY CLASSIFICATION Unclassified	
		2b. GROUP	
3. REPORT TITLE The effects of drugs on human performance: Analytic techniques, new test development, and further studies			
4. DESCRIPTIVE NOTES (Type of report and inclusive dates) Second Annual Report (23 July 1965 - 23 July 1966)			
5. AUTHOR(S) (Last name, first name, initial) Elkin, Edwin H., Baker, William J., Van Cott, Harold P., and Fleishman, E.A.			
6. REPORT DATE 31 August 1966	7a. TOTAL NO. OF PAGES 21	7b. NO. OF REFS 4	
8a. CONTRACT OR GRANT NO. DA 18-035-AMC-282(A) a. PROJECT NO.		8b. ORIGINATOR'S REPORT NUMBER(S) AIR Report No. E25-8/66-AR-2	
c.		8c. OTHER REPORT NO(S) (Any other numbers that may be assigned this report)	
d.			
9. AVAILABILITY/LIMITATION NOTES Qualified requesters may obtain copies of this report from Headquarters, Defense Documentation Center, ATTN: TSA-2, Cameron Station, Alexandria, Va.			
11. SUPPLEMENTARY NOTES		12. SPONSORING MILITARY ACTIVITY U.S. Army Edgewood Arsenal Research Labs Edgewood Arsenal, Md. 20910	
13. ABSTRACT <p>The present report summarizes the second year's effort on a project whose aim is the development of a comprehensive test battery with which to study the effects of drugs on human performance. The project's objectives are to develop a battery of basic human ability tests, to evaluate the battery's sensitivity to a variety of drug conditions, and to validate the battery in terms of its predictability to drug effects in the field.</p> <p>Major accomplishments of the second year were as follows:</p> <ol style="list-style-type: none">1. Completion of detailed analysis of the first year's data resulting in refinement of data analysis techniques, development of a "per cent affected" index, and evaluation of prototype tests.2. Preparation of a Test Administrator's Manual to guide development of future testing procedures.3. Conduct of two studies on a total of 36 medical volunteers to study<ol style="list-style-type: none">a) the effects of medical/psychiatric classification on performance differences;b) the effects of 3580A on selected laboratory and field tests.4. Pilot testing on the Crutchfield Conformity Apparatus to develop materials and techniques for studying drug effects on susceptibility to social influence. <p>KEY WORDS: DRUGS, INCAPACITANTS, BASIC ABILITIES, SOCIAL INFLUENCE, CONFORMITY, AGENT 3580A, TEST ADMINISTRATION MANUAL</p>			

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